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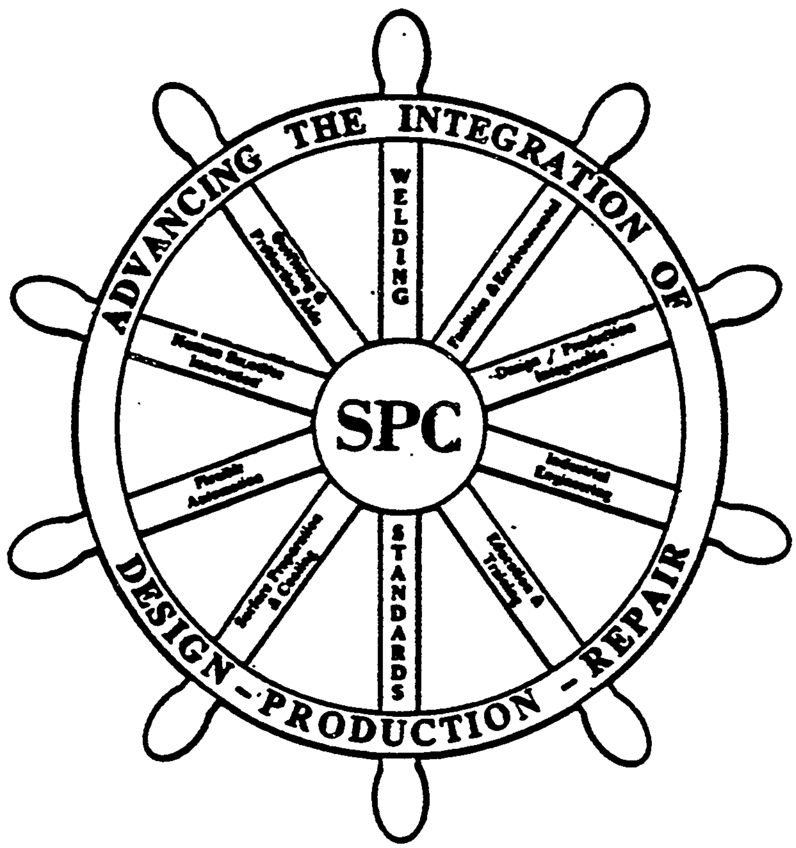

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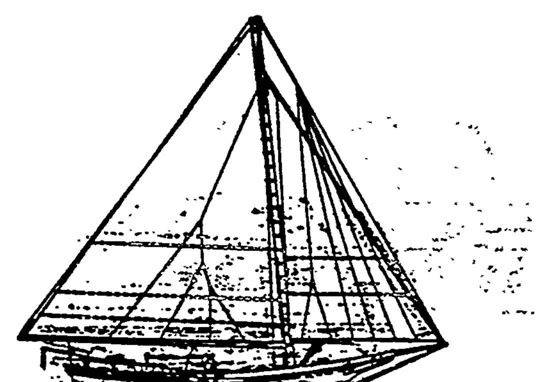

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NAVSEA MCM-1 Product Model

Jeffery D. Arthur's, Member, Naval Sea Systems Command, Washington, D.C.

ABSTRACT

The MCM (Mine Countermeasure Minesweeper) Product Model is the Navy's first true representation of a fully Computer-aided Acquisition and Logistic Support (CALS) oriented information system that integrates automated processes to create, store, retrieve, use and exchange weapon system technical, logistics, manufacturing and management information. The following three processes support the integration:

- data source, definition, and flow analysis;
- configuration baseline establishment and management;
- graphic representation and geometric (three dimensional) modeling.

NAVSEA CALS data flow diagrams document existing processes, organizations, and data flows; subsequent analyses will document specific data elements, their sources, interdependencies, and relationships.

The three dimensional (3D) MCM Product Model integrates engineering, design, logistics, production and configuration management processes. It also produces a variety of information products from the same data base, including piping isometrics, work packages and damage control diagrams.

Three projects have been combined to produce the MCM 3D Product Model. Equipment components designed in the 3D geometric model are linked to a central file of current configuration and logistic information maintained in the Weapon Systems File (WSF) Prototype data base. Access to this central file eliminates the need for many duplicative, independent data bases to generate various reports and products as required by different users. Each component has been assigned a unique functional description and hierarchical structure code that permits integration with the WSF Prototype for access to the appropriate configuration and logistic data. This integrating mechanism also enables access to optically stored technical manuals, engineering drawings, maintenance repair procedures, etc. which comprises the third part of the Model.

INTRODUCTION

Computer-aided Acquisition and Logistic Support (CALS) is a DoD strategy to utilize the latest computer technology and data exchange standards to automate the technical and logistic data associated with weapon system acquisition and support. The twin objectives are to digitize current paper-oriented technical and logistic support data processes, and concurrently to modernize the acquisition and logistics infrastructure. A primary goal of the NAVSEA CALS Program is the integration of current Navy processes which have become increasingly narrow and discipline-specific with regard to the acquisition, development, and modification of technical and logistic support data. Natural integration processes that should exist in ship design and construction have been disrupted by existing methods which resist change. Therefore, NAVSEA CALS is not only concerned with the successful development and transfer of digital data, but with the development of an Integrated Weapon System Data Base (IWSDB). The IWSDB provides the mechanism for establishment of an integrated set of information during acquisition or data base initiation and for maintenance and sharing of that data throughout the life cycle of the weapon system. It requires integration of the infrastructure processes to assure that planning and support are consistent with the defined engineering configuration of the ship and weapon systems.

The MCM Product Model is NAVSEA's first IWSDB. The Product Model captures the natural integration processes of configuration baseline development, digital design, engineering analyses,

and logistic support data. It demonstrates not only digital access to this technical and logistic support data, but also proves the technology concepts behind integrating automated processes to create, store, retrieve, use and exchange weapon system technical, logistics, manufacturing and management information. NAVSEA's implementation of CALS is intended to maximize the total benefits to be derived from this technology, and to mitigate the negative impacts of change in order to stimulate prompt acceptance and implementation of actions.

NAVSEA APPROACH TO CALS IMPLEMENTATION

The Problem

Acquisition programs of the 1970s and 1980s have been confronted with continuously increasing costs, weapon system complexity, and demands for additional documentation. These increases have resulted in the acquisition, development, and maintenance of engineering, technical, and logistic support data becoming increasingly narrow and discipline-specific processes. This is due, in part, to the fact that the specification and receipt of predictable, well-defined, established products reduces the impact of change, its associated risks, and its potential costs. The change in focus rewards the use and independent refinement of existing, established methods to meet restricted, not composite or integrated supportability goals. It has resulted in the loss of natural integration processes that are present in ship design and construction. This loss of integration is manifested in some new weapon systems, where, for example, the initial introduction is plagued with excessive down time, spare parts are not available or do not match maintenance concepts, costs of repairs are high due to part usage vastly exceeding failure predictions, technical documentation and training does not match the configuration of the equipment, etc. Figure 1 shows the multiple configuration baselines which must be maintained for systems and equipment design, construction, and life cycle support. Throughout the life cycle, information from all four configuration baselines will be required. To improve weapon system productivity, quality, timeliness of procurement, and life cycle support, the information and products produced from these baselines must be integrated.

It should be noted that integration is a fragile commodity. Establishing an integrated set of information during the acquisition process in no way guarantees that integration will be preserved. Preservation requires constant, consistent, coordinated, and knowledgeable attention and the presence of a central integration authority responsible for directing and controlling the competing influences resulting from dispersion of responsibility for maintaining that information. Thus, despite a number of initiatives within NAVSEA, the achievement and maintenance of the integration of configuration, engineering, technical, and logistic information has been an elusive goal.

NAVSEA's Solution

The NAVSEA CALS strategy conforms to DOD CALS policy and supports a three phased approach for CALS implementation (see Figure 2). The first phase (present to 1991) emphasizes applying the latest CALS standards to achieve uniform digital data flow. Phase II (1992-1996) focuses on developing an integrated and automated Navy infrastructure to create, store, retrieve, use and exchange digitial data. By the year 2010, Phase III will have promoted the widespread use of CALS products and refined the acquisition process and infrastructure to use the latest technologies.

NAVSEA's approach to implementing CALS technology is not intended to fundamentally change the way the ship is designed or to disrupt the methods for development of specific data within the shipyard (e.g., R&M calculations, provisioning, technical manual development, etc.). It is intended, however, to capture the data that is developed as a natural part of the ship design and shipbuilding process, and establish key relationships among the data to ensure functional integration of information systems and processes. This will reduce or eliminate the need for multiple iterations of the data in redundant files, reduce the volume and cost of deliverables, and improve the quality, accessibility, and responsiveness of the deliverables.

The NAVSEA CALS strategy also promotes the modernization of the infrastructure (i.e., headquarters and field activities and organizations) that will receive, review, store, and use those digital data products. The breadth of NAVSEA activities indicates the enormity of the NAVSEA infrastructure:

- 63 Field Activities
- 32 Detachments
- 107,000 Military and Civilian Workforce
- $26 Billion Annual Budget
- 300 Acquisition Programs
- 850 Foreign Military Sales Cases.

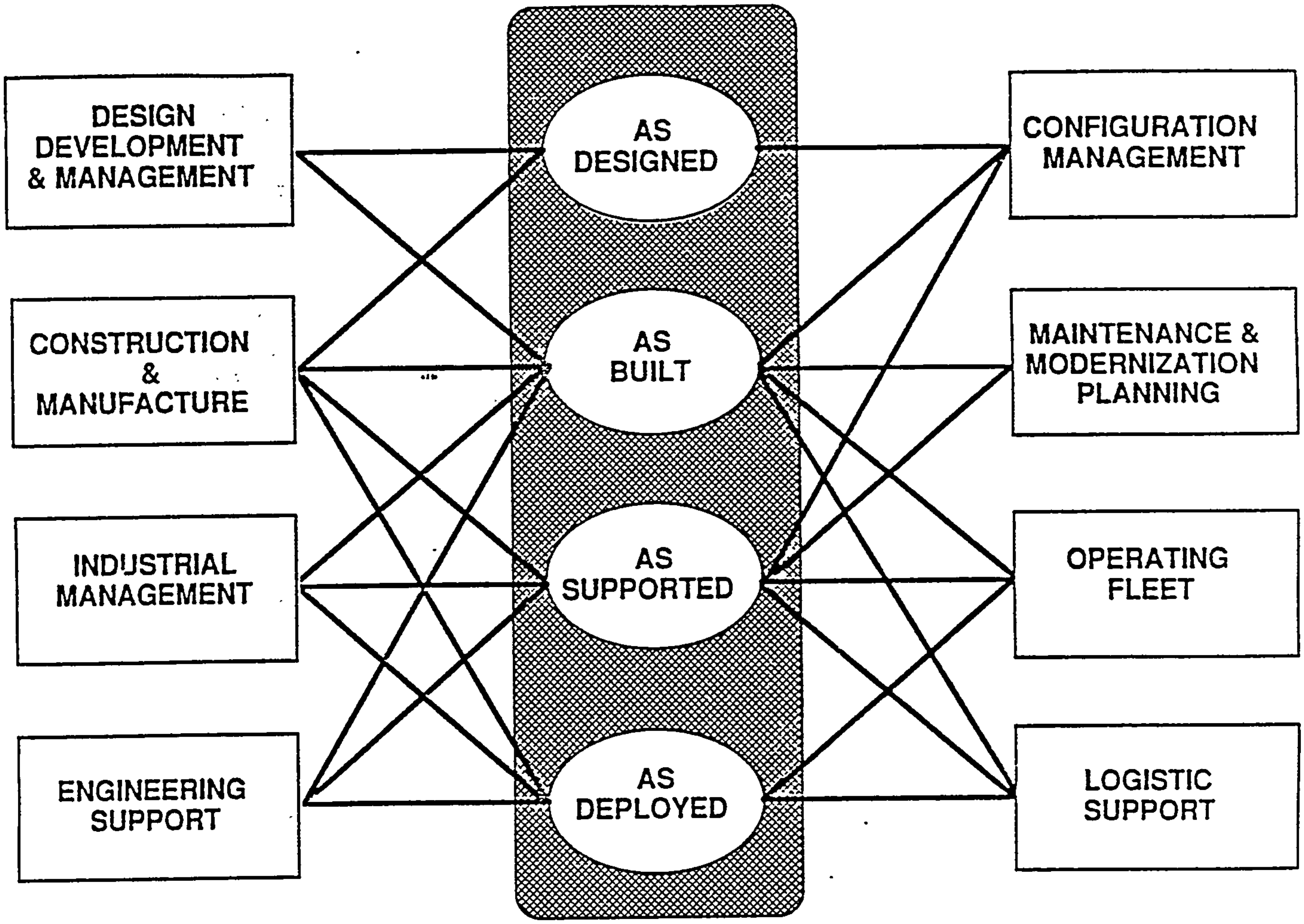

FIGURE 1 - Multiple Configuration Baselines

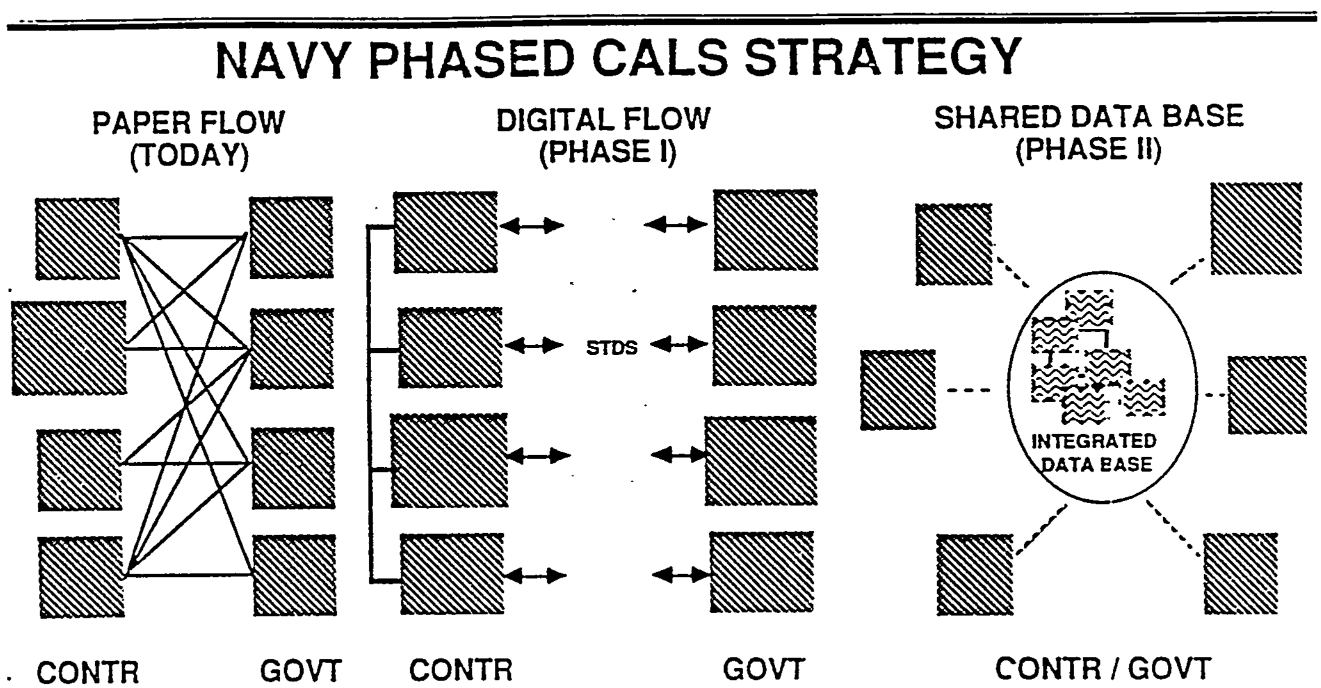

FIGURE 2 - NAVSEA Phased CALS Strategy

Data Flow Analysis

Various activities within the NAVSEA infrastructure are applying CALS technology. The data flows and data relationships in NAVSEA processes, policies, procedures, products, activities, and hardware/software configurations must be identified and analyzed within the context of CALS technology to ensure that NAVSEA proceeds in a responsive, orderly, efficient, and cost effective manner. To help define areas of automation and targets of opportunity for automation and technology infusion in the NAVSEA environment, information modeling techniques have been utilized. Data flow analysis of NAVSEA processes determines what should be incorporated into the IWSDB and how it should be linked together, by defining existing processes (ship design, configuration management, LSA, supply support), activities, and products produced as a result of those processes (technical manuals, drawings, etc.). The products are broken down into data elements to identify redundant data and determine interdependencies. **Figure 3** describes this process for infrastructure modernization and concurrent development of an IWSDB (Phase II).

The MCM Product Model demonstrates that a shared data base environment (Phase II) is accessible today. Prototype demonstrations such as the MCM Product Model are crucial for leading the Navy towards the acceptance and implementation of CALS initiatives. These demonstrations have shown that an important benefit derived from the use of prototypes and working files is the significant advancement of knowledge of the nature, scope, and type of difficulties to be encountered in future applications. This knowledge assists in reducing risks, forcing early resolution of problems, developing and substantiating budget and other resource considerations, and overcoming understandable organization uneasiness in accepting new technology and methodologies.

THE MCM PRODUCT MODEL - A THREE DIMENSIONAL (3D) GEOMETRIC REPRESENTATION OF THE SHIP/SHIP CLASS

Three Dimensional Modeling

Traditional ship design and shipbuilding processes have been drawing-based. Computer Aided Design and Manufacturing (CAD/CAM) systems are replacing much of the draftsmen effort

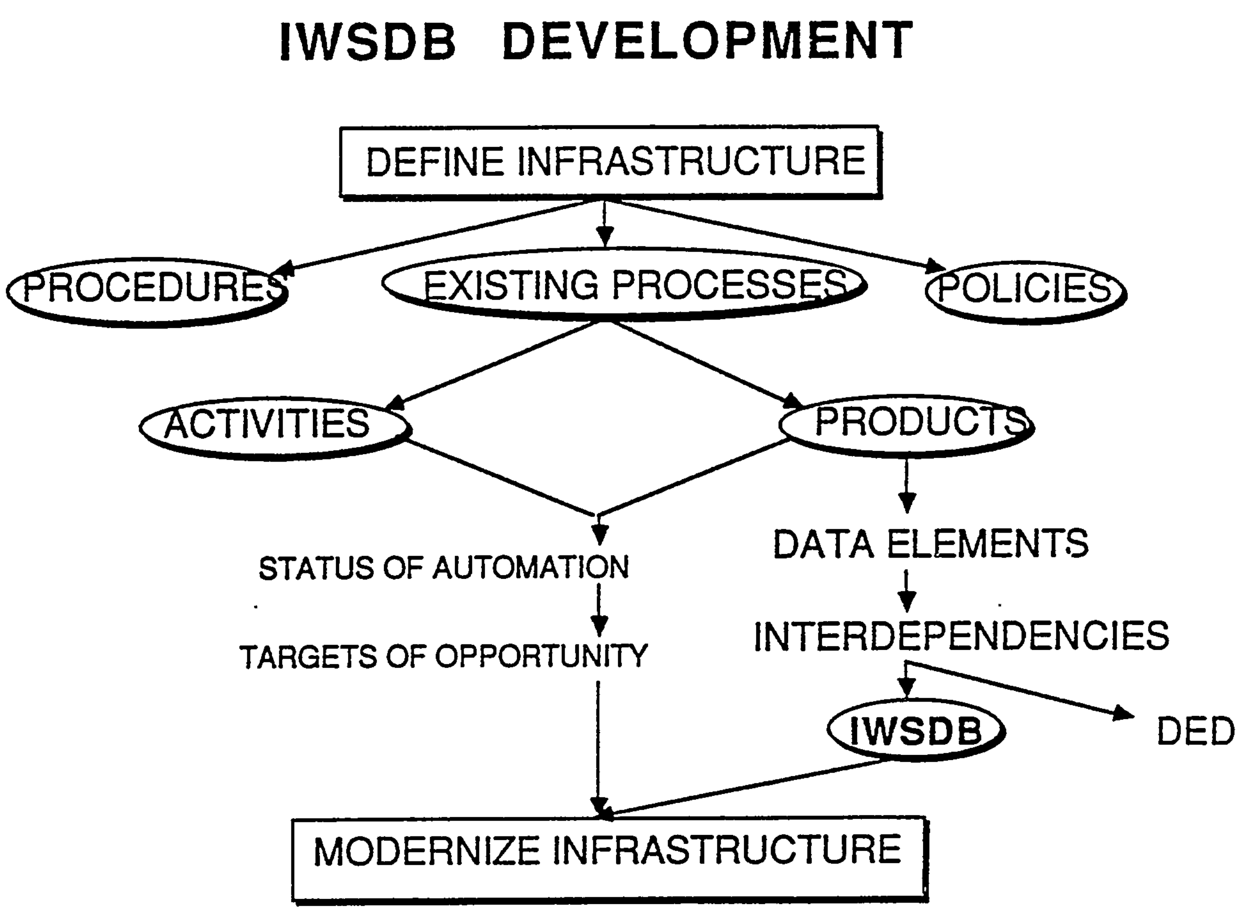

FIGURE 3 - IWSDB Development

with computer generated drawings and files which have reduced the costs of performing traditional drawing functions. This has not, however, significantly altered the approach or methodologies used to develop the final products (e.g., the CAD concept of "layering" closely follows the traditional use of tracings to integrate the design). Thus, integration of the ship systems with the hull structure has been a difficult process with system interference causing significant increases in redesign, rework, and cost. The problem with these systems remains that they are not fully integrated and may have internal inconsistencies. The initial versions of the 3D CAD systems offer new perspectives and many new enhancements and features, but continue to be based on the traditional layering concepts for construction of the model and, therefore, continue to have the consistency problems associated with earlier 2D versions. A second problem is that while these systems provide the basis for the engineering baseline during design and construction, they are very large and may be somewhat cumbersome for daily use in managing a ship or class configuration baseline.

Alternate three dimensional modeling technology uses various mathematical programming to create a single, relational, geometric model of the "as designed," "as built," or some other baseline condition of the ship. The MCM Product Model uses this type of technology to provide a geometric engineering model of structural components and ship systems. It was created from 600-700 engineering drawings provided by Petersen Shipbuilding in Wisconsin. Figure 4 is an external view of the modeled MCM ship. The main advantage of the three dimensional modeling technique is the ability to create an item or entity only once and retain only sufficient attributes to physically and spatially describe the item within the model context. These entities are then related to the specifications, standards, documents, and other data that define the item and to the analytical logistic, configuration, and other technical data. Establishment of these relationships document and support the integration of the engineering, configuration, and logistic data.

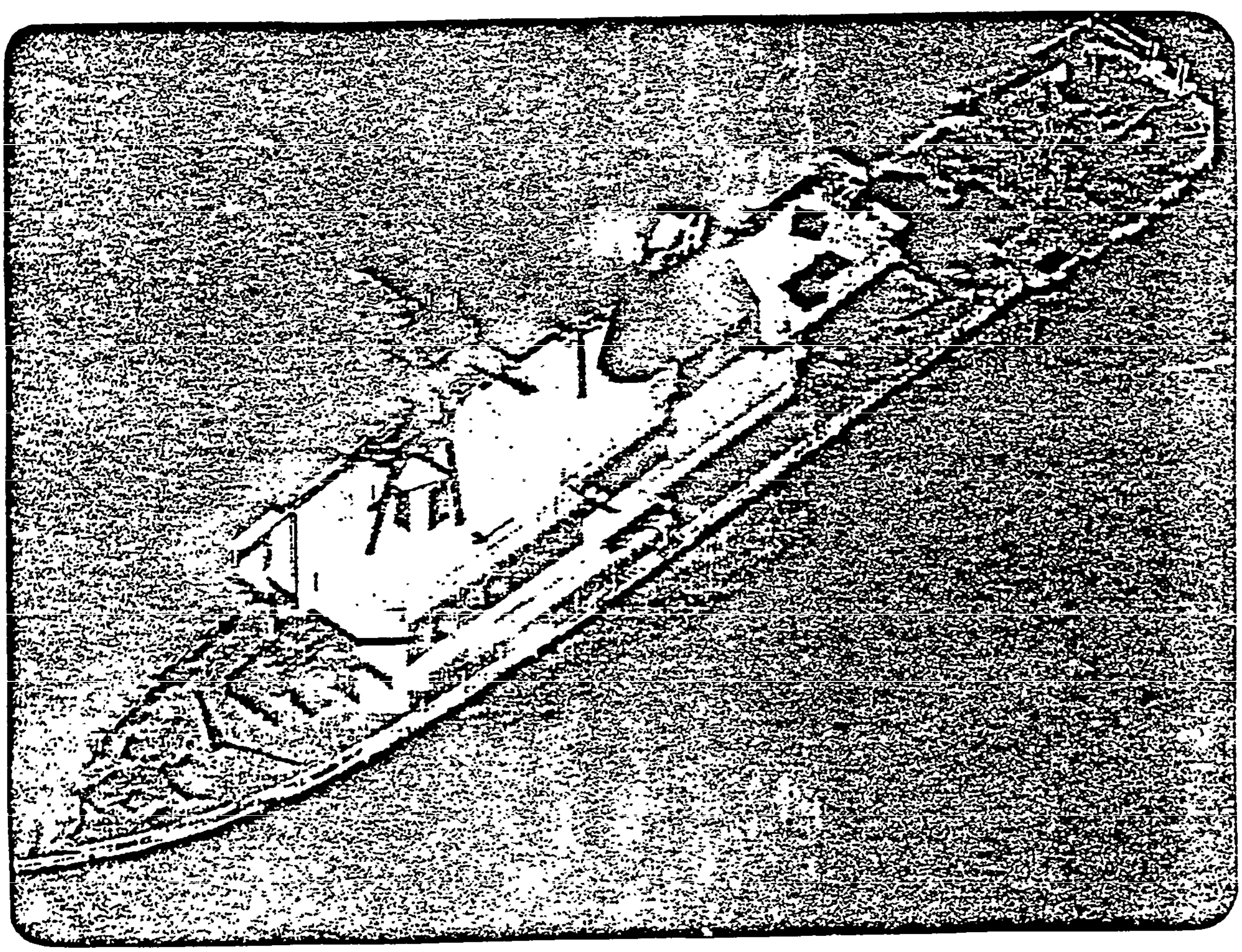

FIGURE 4 - 3D View of Mine Counter-measures (MCM) Ship

CM Product Model Description

Three projects have been combined to produce the MCM 3D Product Model, providing access to a variety of information products and permitting! identification of components, systems and work packages. Figure 5 is a graphic representation of the capabilities and concepts underlying the MCM Product Model. Equipment components designed in the 3D geometric model are linked to a central file of current configuration and logistic informartion maintained in a Weapon Systems File (WSF) Prototype data base. Access to an optical work station comprises the third part of the Model.

Modeling began with hull and external features, followed by the internal structuring and development of the main machinery room. The depicted systems, equipment, and components were developed directly from actual MCM engineering data and technical documentation; that is, the data was not scanned in, but manually converted into 3D. Any position or view can be created, both external and internal to the ship (see Figure 6). The Model provides the ability to simulate a walk through the ship a pace at a time, is look right, left, up, or down, is remove components that costruct vision, and so forth. Figure 7 is a black anc white photograph taken of a Computer Color Monitor screen upon Which the MCM Product Model is being displayed. Although not apparent in the figure, color Coding of Ship systems and structure is included in the model. For example, two of the four diesel engines are shown in dark red, green ventilation pipes, yellow controlers, and blue decking are also shown. The Model can be uses to identify equipment scheduled for removal for SHIPALTs, indicate interference to be removed (e.g., ventilation ducting), detect equipment interference before installation at the waterfront, or entertain "what-if" scenarios. Unlike CAD systems, entities within the 3D Model are coded by structure types so that specific components or systems rather than layers can be removed to accommodate different views. Spatial and other dimensional integrity of individual equipment components are retained in the Model for viewing or manipulation, even though internal structures and equipment are removed.

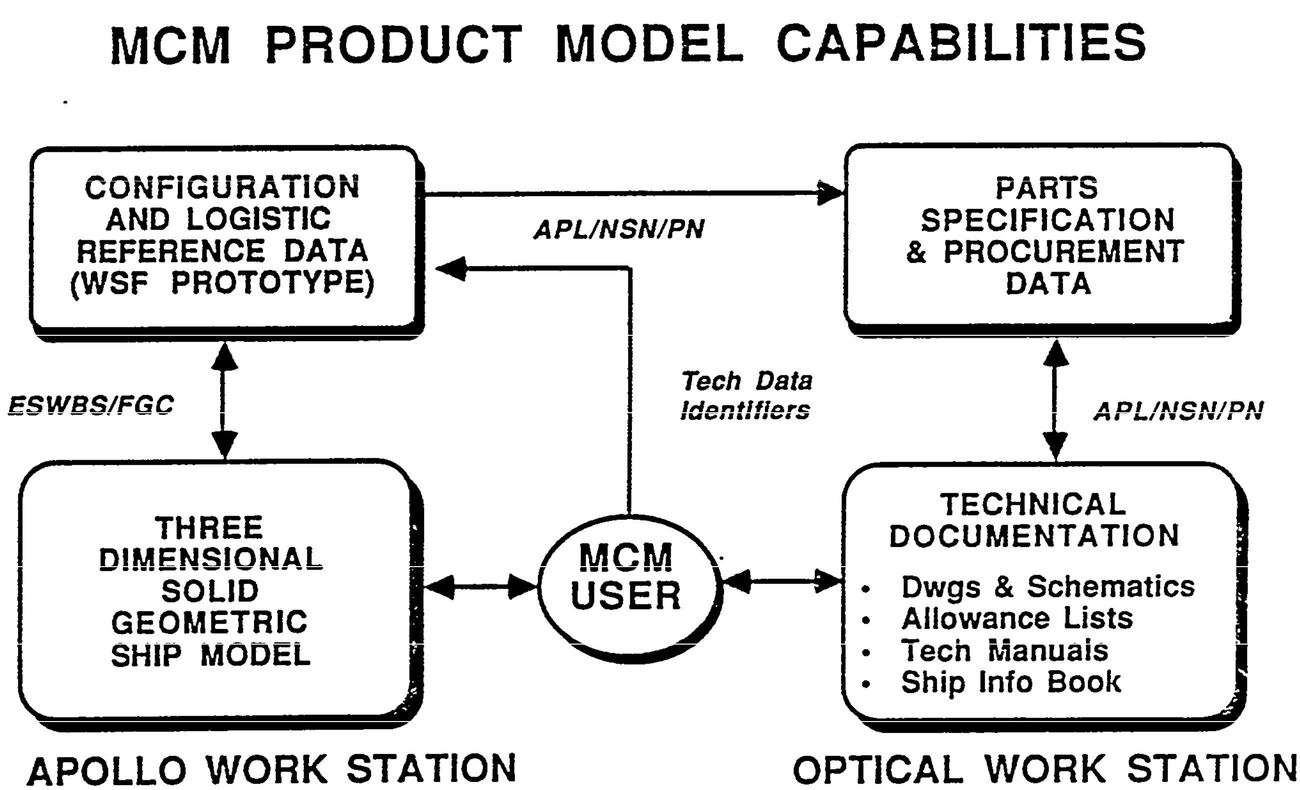

FIGURE 5 - MCM Product Model Capabilities

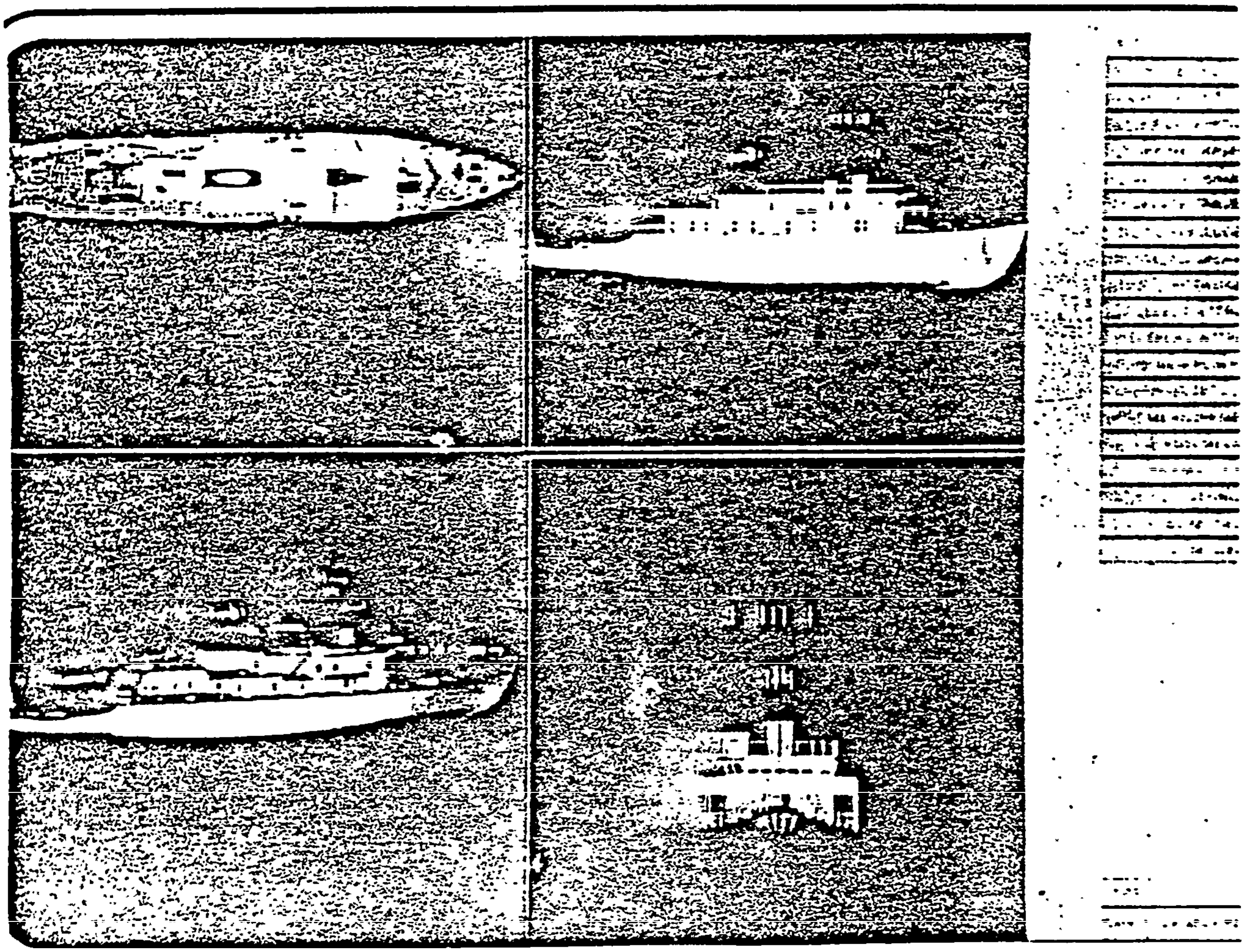

FIGURE 6 - Four Views of the MCM Product Model

The fully relational Model provides you access to the type of information requested as it is needed. Each component in the Product Model has been assigned a unique functional description and hierarchical structure code (Expanded Ship Work Breakdown Structure/Functional Group Code) which permits integration and interaction with respective technical and logistic information stored in a remote configuration and logistics data base. Figure 8 shows the propulsion system. Because of the integrating ESWBS/FGC, the user is able to access the WSF Prototype and retrieve pertinent configuration and loqistics information filed for the propulsion system. The user could also begin inquiry with data information in the WSF Prototype, and then request a three dimensional view of the appropriate equipment. The integrating mechanism is the ESWBS/FSZ. It also enables access to technical data stored on optical disk, so that for example, any technical manual can be retrieved, maintenance repair package reviewed, or engineering drawing examined. An enlarged drawing of the engines is depicted in Figure 9. These documents have been scanned onto optical disk and stored in raster format.

CONFIGURATION AND LOGISTIC DATA SYSTEMS MANAGEMENT

Each equipment component in the MCM Product Model is linked to the WSF Prototype for access to the appropriate configuration and logistic data. Access to this central file eliminates the need for many duplicative, independent data bases to generate various reports and products as required by different users. The configuration and logistic information is logically divided into several groups (or files) that support efficient information management, eliminate redundancy and duplication of data, and ensure that all users have a common, consistent information base to

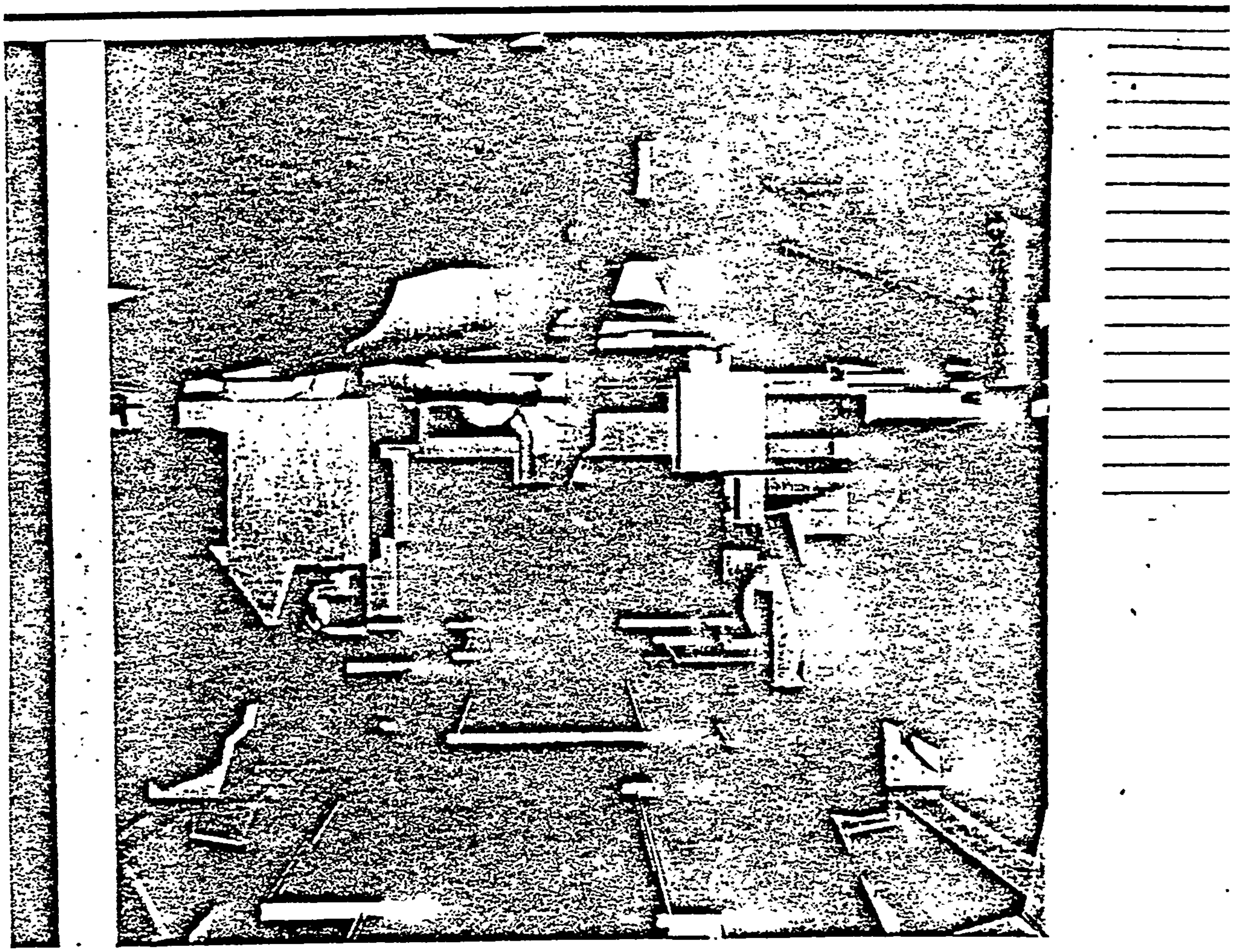

FIGURE 7 - Walk Through the Engine Room

use in executing their functional responsibilities. The division of information allows for management of:

- Ship class and ship configuration baselines;
- System and equipment baselines;
- Technical information (e.g., logistic support and analytic data); and
- The integration of class, ship, equipment, and - technical information (TI) with each other as well as with other files (e.g., three dimensional model and image management systems).

This approach to configuration and logistic information management decreases the number of unconnected and inconsistently structured computer files and replaces them with a system that integrates data managed by a variety of functional activities, makes that data available to appropriate users, eliminates duplicate data, and avoids the potential data accuracy and integrity problems. Each piece of data stored in file must have an accountable activity responsible for its identification, creation, maintenance, accuracy, and currency. Other file users provide quality assurance by identifying perceived inaccuracies to data managers.

__Development of the Product Model fo Configuration Management of th Engineering Baseline__

The Product Model is the key configuration management and integration tool because it defines, at least at the summary level, all configuration items that are contained within the structure. Drawings are the primary tool for establishment, management, maintenance, and control of the engineering configuration baselines of ships, weapon systems, equipment, and components. Use of CAD, CAM, three dimensional models and other automated design, development, and storage media to supplement or replace traditional drawings is a key feature in the development of an IWSDB. The Product Model provides relational structuring of a geometric model with automated linkage to:

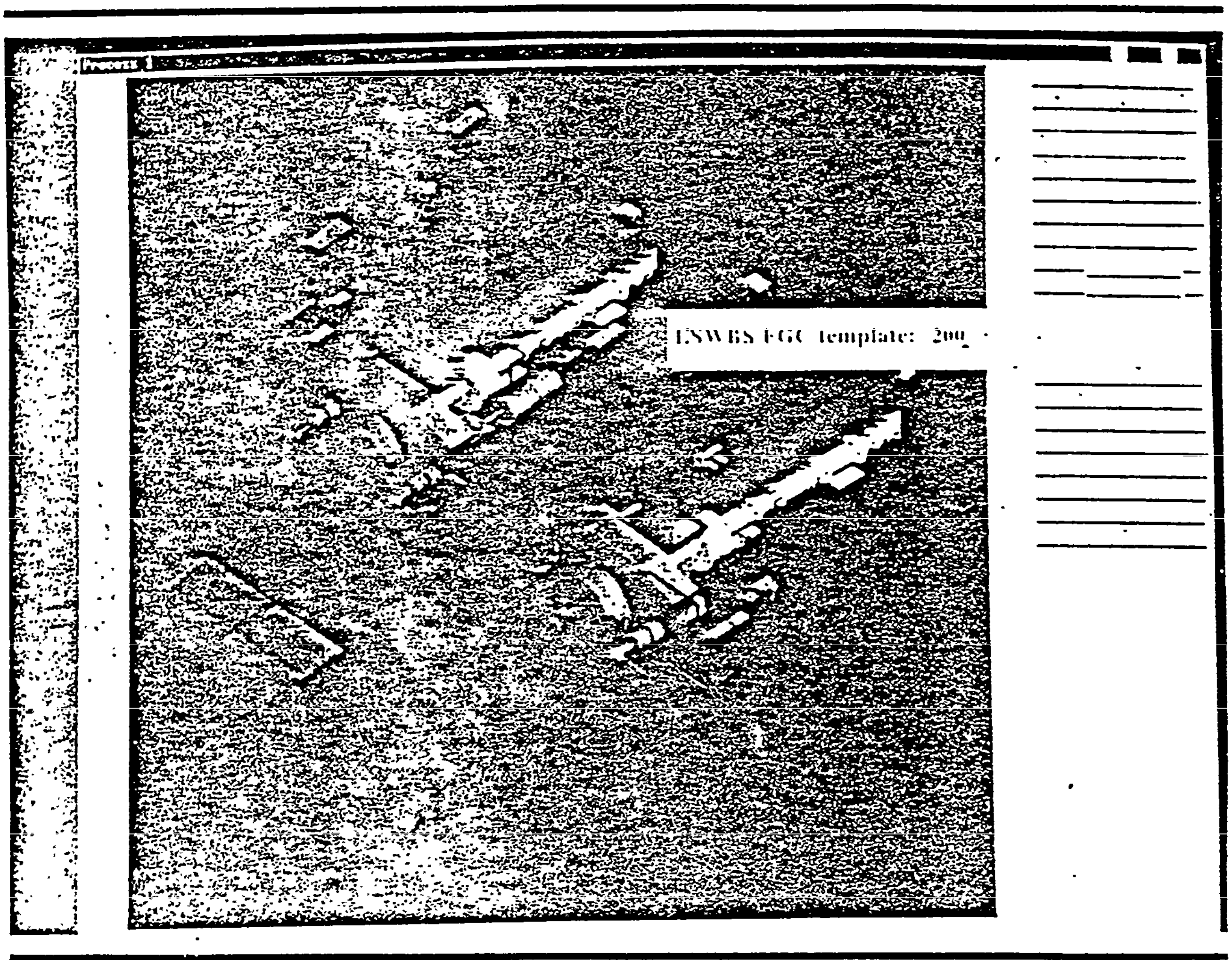

FIGURE 8 - Propulsion System (ESWBS/FGC

- specific entities, systems, and areas within the hull structure;
- Documentation and files that define (e.g., specifications,, standards, performance requirements) and analyze (e.g., R&M, test, weight and moment studies, LSA) systems, equipment and components; and
- Other related configuration, logistic and technical data

The natural processes and relationships which define the ship, its systems and equipment by function, are integrated in the Model with the physical attributes that satisfy those functional requirements based on performance, specifications, and standards.

INFORMATION INTEGRATION

Integration of the Product Model with Design, Construction, Engineering, and Logistic Data

The long-term goal of CALS is for the complete integration of all weapon system information through the use of shared data bases. This is a radical departure in both concept and practice. Ship specifications, military and other Specifications and standards, performance specifications, and operational requirements provide the parameters for the development of procurement specifications. They also define the detailed design of systems that integrate the shipbuilder's procured physical equipments and the Government Furnished weapon systems and equipments within the ship's structure. They provide parameters for analytic processes and performance and engineering studies. The following engineering and logistic deliverables are examples of typical data products that can be prepared using the product model:

Weight Reports
Test Procedures and Reports

Drawing Equipment Data List
Damage Control Diagrams

Compartment Areas-and Volumes
Material Ordering Schedule

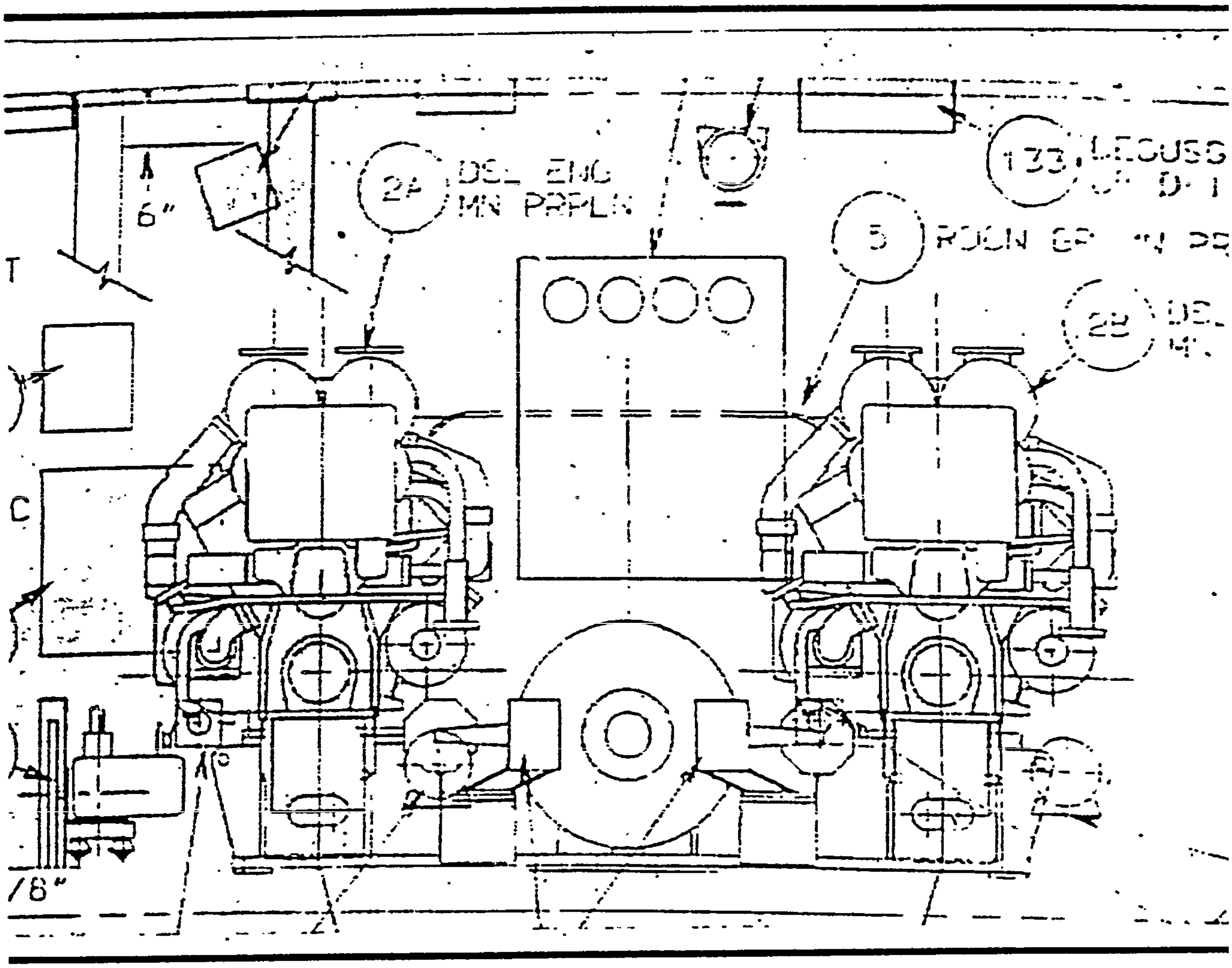

FIGURE 9 - Optically Scanned Drawing

Crew Training Aids
Drawing Schedule

Electrical Load/ Power Analysis
List of Electrical Data

Figure 10 is a sample work package which presents a bill of material, piping isometrics, an internal view of the equipment, and an external view of the ship. All were retrieved from the Model which exemplifies the integrative nature of the Product Model.

of the Product Model with

To provide automated and responsive access to graphic data and text many of the documents have been raster scanned and stored on optical disk. As much of the engineering, technical, analytic, and logistic data is created and presented in paper form, it is bulky and difficult to handle, store, retrieve, transmit, and update. This applies equally to information that is Government Furnished, procured from vendors, and created by the shipbuilder for delivery to the Government to satisfy CDRL requirements (e.g., provisioning documentation, draft technical manuals). Much of this documentation is static or requires only periodic update (e.g., specifications, standards, DIDS and CDRLS, shipbuilder plans), while others require costly, high volume submissions (e.g., cost and performance reports) with monthly or quarterly updates to multiple users, while still others are large volume documents that require periodic update (e.g., drawings, test plans, compartment closure plans). Use of optical storage and retrieval media with raster scanning can significantly reduce both the time and cost of preparing and transmitting data, significantly reduce the volume of files and data storage, and significantly increase the accessibility to, availability of, and responsiveness of all or selected portions of the data and data deliverables.

The MCM Product Model represent the successful combination, integration,

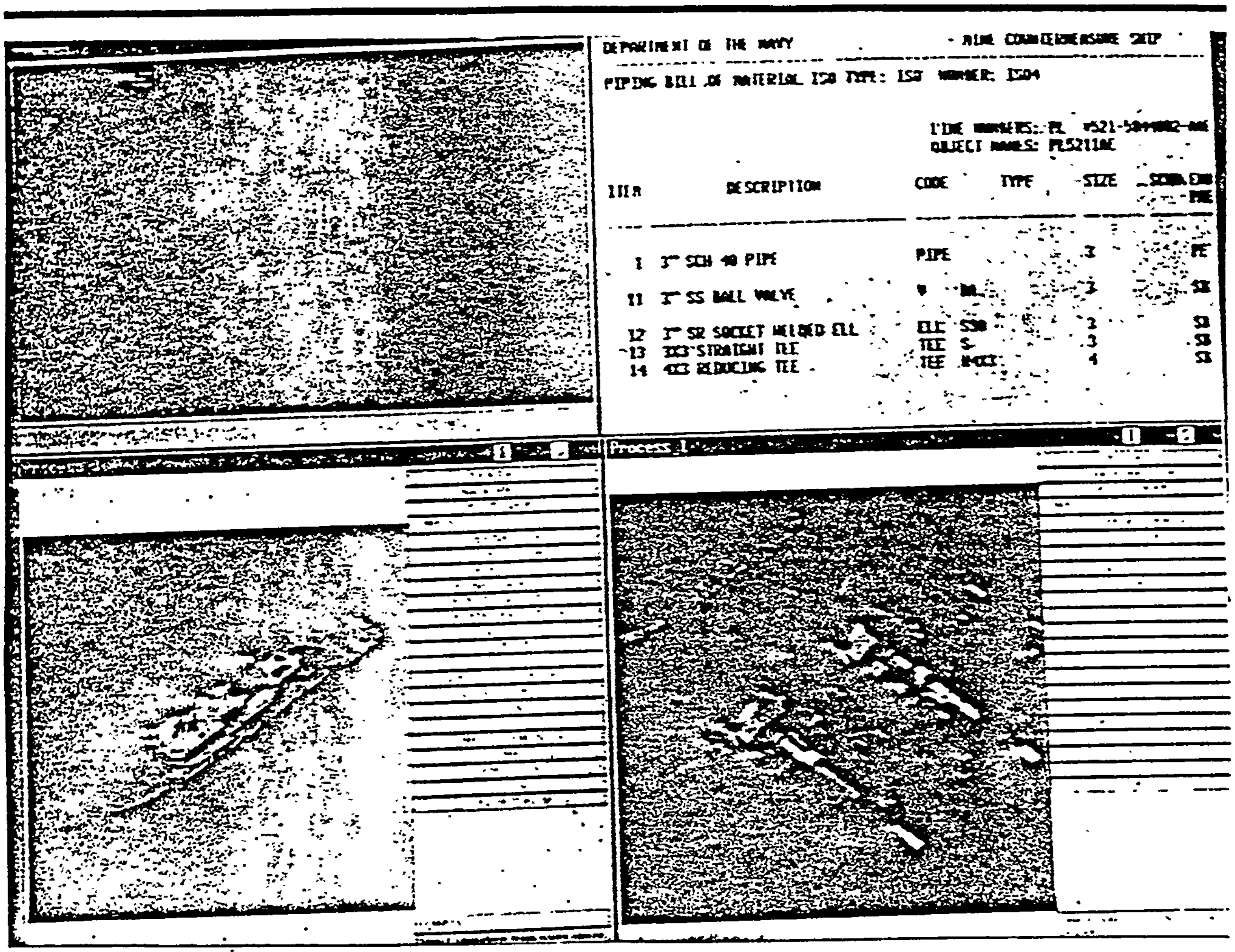

FIGURE 10- Sample Work Package

and interaction of three independent demonstration projects. The combined projects provide access to, extraction of, and use of a variety of information products and permit identification of components, systems, and technical data. The power of the Model is demonstrated in the integration of different data and processes for production planning, configuration management, logistic support, etc. It also enables access to technical data stored on optical disk to enable, for example, retrieval of any technical manual, examination of engineering drawings or review of maintenance repair packages.

WHERE DO WE GO FROM HERE

There are three basic thrusts for future MCM Product Model applications: documentation, assessment, and demonstration.

The development of contractual documents and implementation procedures is key to the successful pursuit of CALS. Examples of the types of documentation to be developed are described below.

Statement of work (sow). Descriptions of the processes required to produce and integrate the basic types of data needed for and resulting from design, construction., delivery, and initial and follow-on logistic support for operational units. The sows should discuss methods for consolidating and coardinating those data into basic, intergated data bases, provide methods for interfacing those data bases and require the bidder to define and describe his or her plan to implement the procedures described and to assess the costs and offsets.

DIDs and CDRLs. Description of the products to be developed and delivered. Implementation of these DIDs/CDRLs will improve operations or reduce costs of preparing final products through reduction of redundant requirements, reduction of many submission requirements (e.g., direct

access to contractor files will obviate the need for many reports), and through the development of integrated files and data structures.

Implementation Instructions. Practical procedural instructions that aid acquisition and life cycle managers, engineering organizations, and logisticians in planning for and executing CALS responsibilities, including interfacing with other IWSDB.

The conversion of contractor efforts from their current paper-constrained, discipline-oriented data development and delivery processes will not be easy. Impacts on cost, schedules, quality, competition, and other factors must be carefully weighed against near- and long-term realizable benefits for the individual program and against the requirements of an evolving and increasingly automated life cycle management system. Similarly, Navy organizations must be able to receive, process, and use the digital data provided. While the need for modernization of the infrastructure is clear, the questions of how much is needed, when, and where present a formidable resource challenge that demands immediate attention.

NAVSEA'S use of prototypes and demonstrations, using live or actual data and documentation and actual on-site workers, has provided significant insight and hands-on experience (e.g., real problems had to be solved in real time and could not be assumed away). This has proven concepts and allowed for initial capability establishment without significant investment. The expansion of this concept to include the establishment of a working model of the MCM Product Model at the planning yard, NSY Charleston, is being pursued as the most effective method for assessing the NAVSEA documentation and resource requirements for full CALS implementation.

CONCLUSION

The MCM Product Model demonstrates integration of engineering, design, logistic, production, and configuration management processes. It also generates a variety of products from the same data base, including piping isometrics, work packages (bill of material combined with view of ship, system and/or equipment), and damage control diagrams. The Product Model not only shows the feasibility of transferring paper data to digital format; it also assigns intelligence to shared or common data, permits different ways of accessing the same data, and integrates various processes. As such, the MCM Product Model demonstrates the feasibility and affordability of implementing CALS for delivered weapon systems in a current environment with semi- or non-automated systems and non-integrated data.

The end result of CALS is the complete transformation of the NAVSEA acquisition and logistic infrastructure to meet the challenges of automated technology advancements and new data management and networking concepts. The MCM Product Model, together with other CALS projects, have demonstrated the viability of applying evolving information integration and automation technology to today's processes. Application of these tools will improve productivity, maximize resources, and at the same time accelerate infrastructure modernization.

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